

secondary over eastern Maryland. Both the main sections moved rapidly northeastward during the night, and on the morning of the 20th, the Virginia one was over the Island of Nantucket (29.18 inches). By evening it had passed over Newfoundland, and in the meantime the northern section had disappeared.

As stated above, no strong winds occurred, except along the Maine coast. There were, however, some very heavy snows over portions of New York and New England.

*Storm of March 24-27.*—On the morning of March 24 a well-defined low extended in the form of a narrow trough from eastern New Mexico to southern Minnesota, with a center of disturbance at each end, the northern one disappearing to the northward of Lake Superior during the succeeding night. On the morning of March 25 the southern low was central over Oklahoma (Altus, 29.14 inches), and SE. storm warnings had been ordered on the previous evening along the Gulf coast from Bay St. Louis, Miss., to Cedar Keys, Fla. Orders were issued at 3 p. m., March 25, to change these warnings to SW. at sunset, and SW. warnings were also ordered on the Atlantic coast from Jacksonville, Fla., to Charleston, S. C. At 8 p. m. the center of the storm was over SE. Iowa (Keokuk, 29.02 inches), and advisory warnings for strong winds and rain were sent to open ports on Lake Michigan. By the evening of March 26 the storm center was northeast of Lake Superior, and on the morning of March 28, it was north of Newfoundland with undiminished intensity.

The warnings issued on the 24th and 25th for the Gulf coast and the Jacksonville-Charleston section of the Atlantic coast were verified, except on the Atlantic coast, where only fresh winds occurred.

Still another severe storm appeared during the 29th north of British Columbia and developed to the southeastward. This storm will be discussed in the MONTHLY WEATHER REVIEW for April, 1920. The SE. storm warnings ordered at 3 p. m., March 25, on the New England coast were ordered as a matter of precaution, as a disturbance was moving northward over the western Atlantic Ocean, only a short distance from the coast, and its intensity was problematical. No strong winds followed, and the warnings were unnecessary.

#### WARNINGS FROM OTHER DISTRICTS.

*Chicago, Ill., forecast district.*—The month was marked by the movement in rapid succession of a remarkable series of low-pressure areas across this forecast district. The barometer was abnormally low in most of the storm areas. As the disturbances advanced they were attended by general rains and high winds and even gales.

The storm which crossed the district during the 3d and 4th was the only one that was followed by a well-marked cold wave, the highs not following the lows in the usual order with marked changes in temperature.

The disturbance which advanced eastward across the Rockies on the 2d and reached Kansas on the 3d was one rather of the winter type, and by the evening of the 4th it had crossed the Upper Lake Region. Snow was general on its northern and western sides, with strong winds and falling temperature. Warnings to live-stock interests were issued on the morning of March 2 to South Dakota, Nebraska, and Wyoming points. Additional warnings were sent to Nebraska on the morning of the 3d and to Kansas and west Missouri. The messages

contained advices of snow, cold weather, and strong northwest winds. Cold-wave warnings were also issued on the 3d to the Central Plains States, and they were extended on the morning of the 4th to Illinois and a portion of Wisconsin. These warnings, as well as the advices to stock interests, were fully verified, and it is believed that transportation and stock were protected from the severe conditions which followed. The cold was persistent for several days following the passage of this storm, temperatures being particularly low in the Northwest. A reading of  $-32^{\circ}$  was reported at Billings, Mont.

Beginning on the 10th, the weather conditions became especially active. The storm which passed across the district on the 10th and 11th covered a wide area, but the barometer readings were not especially low. However, a few days later, in the storm which crossed over the more northerly States on the 14th to 16th, the pressure was very low, 28.56 inches being reported at Moorhead, Minn.

While the pressure in the following two storms was also low, it was not until the 28th that the reading again fell below 29 inches. On the morning of that day the barometer at Sioux City, Iowa, registered 28.96 inches. In the southeast quadrant of this storm, far from the center, in northern Illinois, three distinct tornadoes developed, which caused damage amounting to \$3,150,000, 225 houses were wrecked, and 28 lives were lost, and 300 injured.

There were seven storms in all which crossed the district, and each one was attended by more or less severe gales. Generally speaking, it was probably the windiest month in this forecast district for a long period of years. Warnings of the gales were given in advance of these storms to the vessel interests on Lake Michigan maintaining winter navigation.

Warnings of snow and colder, with strong northwest winds, were sent to the live-stock interests on the morning of the 11th to points in Kansas and west Missouri, and on the morning of the 17th to Wyoming and west Nebraska. The conditions following these warnings were not as severe as those of the storm during the early days of the month, but nevertheless the warnings were justified.—H. J. Coz.

*New Orleans Forecast District.*—Storm or small craft warnings were issued for the Texas coast on the 3d, 11th, 14th, 24th, and 27th, and for the Louisiana coast on the 4th and 24th. These warnings were generally justified. No general storm occurred without warnings.

A cold wave overspread the district during the 3d, 4th, and 5th, for which timely warnings were issued. No cold wave of any importance occurred without warning.

Five weather warnings were issued as occasion required.—I. M. Cline.

*Denver Forecast District.*—The month was characterized in the Denver Forecast District by abnormally low temperature and windy weather. An unusually large number of deep storms from the Pacific coast crossed the district, causing frequent serious delays in telegraphic service and some interruption to railroad traffic in the mountain districts. Some winter grains were uncovered in eastern Colorado by strong winds. As is usual in storms that cross the mountains, an excess of precipitation occurred on the western slope and a deficiency in the districts east of the mountains. Record-breaking cold weather prevailed in eastern Colorado in the fore part of the month, an anticyclone of marked intensity spreading

slowly southward along the eastern slope, followed by several days of severe cold weather for the season of the year. Cold wave warnings were issued for eastern Colorado on the morning of the 3d. The warnings were verified in the greater part of the area for which the warnings were issued. However, still lower temperatures occurred in eastern Colorado on the mornings of the 6th and 7th, several stations reporting the lowest temperatures of record for March.—*Frederick W. Brist.*

*San Francisco Forecast District.*—The pressure distribution over the Pacific Slope during March showed a marked change from that of the two preceding months. The hitherto prevalent high areas over the Rocky Mountain and Plateau regions gave way to frequent low areas moving in over British Columbia, and the Pacific HIGH moved southward and impinged on the southern Oregon and California coasts.

This pressure distribution was nearer the normal seasonal condition than had obtained heretofore this winter and precipitation occurred oftener and in greater amounts throughout this district. In eastern Oregon, western Idaho, northern Nevada, and California, except on the extreme north coast, the precipitation was above normal, the excess being greatest in the San Joaquin valley and southern California. In those sections where the precipitation was below the average, the amounts were greater than in either of the two preceding months. The snowfall on the ground in the mountain regions remains much below the average.

The temperature was generally slightly below normal in all sections, and there were no marked warm or cold spells.

On 11 days warnings were issued for light to heavy frosts in portions of California. The warnings were generally verified, but the frosts were not severe enough to cause serious damage.

Storm warnings were issued 15 times during the month and in most instances were verified.

On the 21st and 22d frequent reports were received by radio from the S. S. *Manoa*, at that time in a severe storm about 500 to 600 miles off the central California coast. The reports were of great assistance in determining the extent and probable duration of the storm at that time making its appearance on the coast.—*G. H. Willson.*

#### RIVERS AND FLOODS, MARCH, 1920.

By ALFRED J. HENRY, Meteorologist in Charge.

[Weather Bureau, River and Flood Division, Washington, Apr. 30, 1920.]

March is preeminently the month of maximum flood frequency east of the 100th meridian and the current month was no exception, although it may be said that there was no severe and widespread flood in any part of the country.<sup>1</sup>

At the beginning of the month the snow cover in the Northern Middle Atlantic States and New England was of very considerable depth and by reason of the prevailing low temperature of the preceding months it was well packed and contained a large water content. The presence of this great snow blanket which ranged from 10 to 15 inches in depth over northern Pennsylvania and New

York increasing to between 2 and 3 feet over New England and the near approach of thawing weather was the cause of some alarm in many localities. As often happens in the case of well-packed snow, the flood menace is not great; in this case the flood waters from the melting snow and moderate rains passed down the streams generally without special incident.

There were rather frequent short periods of rain with temperatures above freezing in northern watersheds but at no single time did the elements combine to cause disastrous floods.

The rivers of eastern Pennsylvania reached flood stage on the 5th and 6th as the result of thawing weather and rain coupled with the breaking up of the ice. The mills of Manayunk, Philadelphia, were obliged to remove perishable goods from the first floor of their establishments and to suspend operations for two days on account of high water. About a week later a short spell of warm weather attended by rain started a general break up of the ice in the streams of eastern New York and eastern Pennsylvania. Many ice gorges were formed and there was more or less local flooding as a result. The Hudson at Albany and Troy passed above the flood stage on several occasions during the month and remained close to flood stage at the end of the month.

The ice broke up in the Connecticut on the closing days of the month, starting on White River on the 25th. There was more or less flooding of the lowlands and damage that could not be prevented. The Connecticut at Hartford remained in flood until April 9.

The Susquehanna of Pennsylvania and New York after an unusually long icebound period began to break up in the upper tributaries in Pennsylvania as early as the 6th and was clear of ice down to Harrisburg by the 13th. The principal flood occurred on the 13th and 14th.

Moderate rain floods occurred in the streams of the South Atlantic and East Gulf drainage, also on the upper Trinity of the West Gulf drainage.

In the Great Lakes drainage the majority of the streams in lower Michigan and northern Ohio and Indiana reached flood stages during the period 12th to 17th.

In the upper Mississippi drainage in Wisconsin and Minnesota the streams did not attain flood stages until near the end of the month. The heavy rain of the 25th and 26th, together with the runoff from melting snow, caused a sharp rise in the streams, which crested with slightly above flood stages on the closing days of the month. The crest of the flood in the upper Mississippi on the 31st was below Reeds, Minn.

*The Mississippi proper.*—As above indicated the spring rise had set in at the close of the month and there was also a moderate flood in the river below the mouth of the Missouri. The upper tributaries of the Ohio were in flood, some as early as the 6th and practically all of them again on the 13th. By the time flood waters of the last named had reached the lower reaches of the streams heavy rains over Kentucky and Tennessee caused floods in the rivers of those States which synchronizing with high water in the main river as well as in the Mississippi below St. Louis resulted in a stage of 51.4 feet on the Cairo gage on the 31st. On that date the Mississippi was in flood from below Reeds, Minn., to Arkansas City, Ark. The subsequent history of this Mississippi flood belongs to the record of April.

<sup>1</sup> For note on conditions in the West, see "The snowfall in the Western States, winter 1919-20, p. 156.